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Development and delivery of the BOOST (Better Outcomes for Older adults with Spinal Trouble) intervention for older adults with neurogenic claudication

Lesley Ward [a,*], Esther Williamson [a], Zara Hansen [a], David P. French [b], Graham Boniface [a], David Rogers [c], Sarah E. Lamb [a], on behalf of the Better Outcomes for Older Adults with Spinal Trouble BOOST Group

[a] *Nuffield Department of Rheumatology, Orthopaedics and Musculoskeletal Sciences, University of Oxford, Botnar Research Centre, Windmill Road, Oxford OX3 7LD, UK*

[b] *Manchester Centre for Health Psychology, School of Health Sciences, University of Manchester, Coupland 1 Building, Oxford Road, Manchester M13 9PL, UK*

[c] *Centre for Musculoskeletal Medicine, Royal Orthopaedic Hospital NHS Foundation Trust Birmingham, Bristol Road South, Birmingham B31 2AP, UK*

Abstract

Neurogenic claudication due to spinal stenosis is a common cause of disability in older adults. Conservative treatments are a favourable treatment option. This paper describes the development and delivery of the BOOST (Better Outcomes for Older adults with Spinal Trouble) intervention, a physiotherapist-delivered physical and psychological intervention for the management of neurogenic claudication in older adults. The BOOST intervention is being tested in a multi-centre, randomised controlled trial in UK National Health Service Trusts; delivered by physiotherapists registered with the Health and Care Professionals Council. Participants are aged 65 years or older, registered with a primary care practice, and report symptoms consistent with neurogenic claudication. Intervention content and delivery was initially informed by clinical and patient experts, research evidence, and behaviour change guidelines; and refined following an intervention development day attended by researchers, health professionals, and Patient and Public Involvement representatives. The BOOST intervention comprises 12 group sessions, promoting sustained adherence with a long term home and physical activity programme. Each session includes education and group discussion, individually tailored exercises, and walking. Initial exercise levels are set at a one-to-one assessment. Continued home exercise adherence and increased physical activity following completion of the sessions is facilitated through support telephone calls.

Trial registration ISRCTN12698674.

Keywords: Neurogenic claudication; Spinal stenosis; Exercise; Randomised controlled trial; Intervention

* Corresponding author at: Centre for Rehabilitation Research, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Botnar Research Building, Windmill Road, Oxford OX3 7LD, UK.

E-mail addresses: lesley.ward@ndorms.ox.ac.uk (L. Ward), esther.williamson@ndorms.ox.ac.uk (E. Williamson), zara.hansen@ndorms.ox.ac.uk (Z. Hansen), david.french@manchester.ac.uk (D.P. French), graham.boniface@ndorms.ox.ac.uk (G. Boniface), david.rogers4@nhs.net (D. Rogers), sarah.lamb@ndorms.ox.ac.uk (S.E. Lamb).

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Introduction

Neurogenic claudication (NC) is the symptomatic presentation of lumbar spinal stenosis (LSS). Symptoms include intermittent pain, tingling, numbness, weakness, heaviness, or fatigue, radiating into the buttocks and legs; often accompanied by low back pain [1]. NC is commonly triggered or worsened by spinal extension, typically during prolonged standing or walking; and relieved by spinal flexion, such as sitting or forward bending [1]. This symptom profile directly impacts physical and social independence, through reduced mobility and health-related quality of life [2–4].

NC is a common cause of disability in adults over 65 years of age [2]. LSS treatment includes both surgical and conservative options [1]. A recent Cochrane review concluded no clearly superior benefit of surgical compared to conservative treatments for LSS-related pain or disability [5]. However, conservative treatments have a lower rate of side effects, making them a favourable treatment option [5].

There is a strong theoretical underpinning, and limited clinical and research evidence, for a physiotherapy intervention for NC. Stretching exercises may relieve pressure on spinal nerves and blood vessels; and aerobic exercise such as walking may improve circulation within spinal blood vessels, alleviating ischaemic changes [6]. However an absence of high quality trials precludes recommendations of physiotherapy for NC [2,7,8].

Overview of the BOOST trial

Full details of the BOOST (Better Outcomes for Older adults with Spinal Trouble) trial protocol are published separately [9]. Briefly, BOOST is a multi-centre, two-armed randomised controlled trial, comparing a physiotherapist-delivered physical and psychological intervention for NC in older adults (henceforth referred to as the BOOST intervention) to Best Practice Advice (Fig. 1). The trial is delivered in National Health Service (NHS) physiotherapy departments, to community-dwelling adults, aged 65 years and older, self-reporting symptoms consistent with NC. The primary outcome and time point is low back pain-related disability at 12 months, measured by the Oswestry Disability Index [10,11]. Recruitment opened 25th July 2016, and was completed on 29 August 2018.

This paper, reported in accordance with Medical Research Council guidelines for complex interventions [12], Template for Intervention Description and Replication (TIDiER) checklist [13], and Consensus on Exercise Reporting Template (CERT) [14], provides a detailed description of the rationale and development of the BOOST intervention. Specific behaviour change techniques are defined according to the Coventry, Aberdeen & London – Refined (CALO-RE) taxonomy [15].

Overview of the BOOST intervention

A key feature of the BOOST intervention is delivering an individually tailored education and exercise programme within a supervised group setting. The manualised, standardised programme comprises twelve 90-minute group-based sessions delivered over a 12-week period (Table 1). Prior to Session 1, participants attend an individual one hour assessment, to establish their exercise baseline levels. Session frequency reduces from twice weekly to fortnightly over the 12 week intervention period, with a concurrent, individualised home programme introduced from Week 3. Within 3 months post-intervention participants receive two short telephone calls from the physiotherapist, to facilitate adherence to the home programme (Fig. 1).

All sessions follow a standardised format: physiotherapist-facilitated education and group discussion (30 minutes), followed by a 60 minute supervised exercise programme comprising warm-ups (~5 minutes), an exercise circuit (~30 minutes), and a walking circuit (~20 minutes). The education content is sequenced to support participants' uptake and adherence of home exercise (Table 1).

The progressive exercise programme, presented in Table 2, begins with four seated warm-up exercises, targeting joint mobility. The exercise circuit consists of six exercises, targeting strength, balance, and flexibility; and the walking circuit includes equipment to challenge speed and balance. The programme is individually tailored, and progressed over the 12 week programme to ensure participants maintain a prespecified target intensity as their physical ability improves.

Rationale and development of the BOOST intervention

A conceptual model of the change processes, active intervention elements, and potential moderators [16] of the BOOST intervention is presented in Fig. 2. Our challenge was to design a multi-dimensional programme, addressing both physical and psychological factors relating to aging, pain, and inactivity, which was acceptable to users and deliverable within routine NHS practice. The authors considered clinical guidelines for exercise in older adults [17], National Institute for Health and Care Excellence guidelines for individualised behaviour change interventions [18] and low back pain and sciatica in over 16 s [19], research evidence on disability and the clinical effectiveness of interventions for both aging and NC populations, and current clinical practice. Additionally, the authors sought a patient perspective, qualitatively exploring older adults' lived experiences of NC and preferences for physiotherapy treatment [20].

The authors identified two parallel and synergistic approaches: 1) exercises targeting strength, balance, flexibility, and endurance; performed at a dose sufficient for physiological change in older adults [21]; and 2) educa-

Table 1
Schedule and content of the 12-week BOOST intervention.

Week	Session	Education content	Exercise content	Key behaviour change strategies (CALO-RE taxonomy [15])
Pre-session assessment of NC and physical activity levels (individual baseline setting)]		Building the therapeutic relationship; LSS presentation and prognosis; staying active; modifying activities; flexion exercises for acute symptom relief; pain medications.	Demonstration of all circuit exercises; individual baseline setting for the strength and balance exercises and the walking circuit.	Consequences of behaviour (individual); provide instruction on how to perform a behaviour; demonstrate a behaviour; feedback on performance.
1	1	*Theme:* introduction to BOOST. *Topics*: overview of NC; role of activity in managing NC; lumbar flexion for pain relief; exercising guidelines.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, performed at baseline levels. *Home programme*: no.	Consequences of behaviour (individual); feedback on performance.
1	2	*Theme*: increasing mobility – the role of pain. *Topics*: pain $\neq$ damage; sensitivity and deconditioning; pain memory; medication use.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme:* no.	Consequences of behaviour (individual); feedback on performance; set graded tasks.
2	3	*Theme*: increasing mobility – improving strength and fitness. *Topics*: age- and activity-related muscle changes; benefits of exercise; overcoming barriers to exercise; fear avoidance behaviour.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme:* no.	Consequences of behaviour (Individual); Feedback on performance; Set graded tasks.
2	4	*Theme*: increasing mobility – modifying activities. *Topics*: under/over-activity cycle; pacing; baseline setting; graded activity; managing symptom aggravation.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme:* no.	Consequences of behaviour (individual); feedback on performance; set graded tasks.
3	5	*Theme*: increasing mobility – home programme Phase 1. *Topics*: exercising safely at home; integrating exercise into daily routines; using exercise planners; introducing Phase 1 programme.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – Phase 1*: warm-ups; individually tailored seated strength exercises. Request to complete once before Session 6.	Consequences of behaviour (individual); feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice.
3	6	*Theme*: increasing mobility – home programme Phase 2. *Topics*: peer discussion of Phase 1 home exercise experiences; exercise barriers and facilitators; overview of Phase 2 programme; concerns/ideas for managing home exercises.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – Phase 2*: warm-ups; individually tailored circuit exercises. Request to complete once before Session 7.	Feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
4	7	*Theme*: increasing mobility – building confidence. *Topics*: peer discussion of Phase 2 home exercise experiences; exercise barriers and facilitators; fear and activity cycle; falls risk factors; walking aids.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – Phase 2*: warm-ups; individually tailored circuit exercises. Request to complete once before Session 8.	Consequences of behaviour; feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.

5	8	*Theme*: increasing mobility – home programme Phase 3. *Topics*: peer discussion of Phase 2 home exercise experiences; exercise barriers and facilitators; overview of Phase 3 programme; use of walking planners.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home Programme – Phase 3 (full programme)*: warm-ups; individually tailored circuit exercises and walking programme. Request to complete once before Session 9.	Feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
6	9	*Theme*: increasing mobility – increasing independence. *Topics*: peer discussion of Phase 3 home exercise experiences; integrating exercise into daily routines; planning a long-term independent home exercise programme.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – full programme; individually tailored.* Request to complete twice weekly.	Consequences of behaviour; feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
7	–	–	*Group based:* no. *home programme – full programme; individually tailored.* Request to complete twice weekly.	
8	10	*Theme*: improving mood. *Topics*: peer discussion on home programme; exercise confidence and routines; exploring links between pain, mood, and activity; noted benefits of exercise.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – full programme; individually tailored.* Request to complete twice weekly.	Consequences of behaviour; feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
9	–	–	*Group-based:* no. *Home programme – full programme; individually tailored.* Request to complete twice weekly.	
10	11	*Theme*: maintaining an active lifestyle (1). *Topics*: peer discussion on home programme; exercise confidence and motivation; positive differences in activities or mood; information sharing on groups and activities available in the local community.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – full programme; individually tailored.* Request to complete twice weekly.	Consequences of behaviour; feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
11	–	–	*Group-based:* no. *Home programme – full programme; individually tailored.* Request to complete twice weekly.	
12	12	*Theme*: maintaining an active lifestyle (2). *Topics*: peer discussion on home programme; review of education and behavioural concepts; coping with flare-ups.	*Group-based*: warm-ups; individually tailored exercise and walking circuit, progressed as appropriate. *Home programme – full programme; individually tailored.* Request long-term adherence to complete twice weekly.	Consequences of behaviour; feedback on performance; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.
Post-session support (phone calls ×2)		Review of exercise progress and adherence; discussion on exercise confidence and routines; re-iteration of behaviour techniques as applicable to each participant.	N/A	Consequences of behaviour; set graded tasks; goal setting (behaviour); action planning; teach prompts/cues; prompt practice; barrier identification/problem solving.

Table 2
Description of the physical components of the BOOST intervention.

Physical component	Baseline	Progression	Suggested equipment	Home programme suggestions
Warm-ups (seated) *Single arm raises;* *Trunk rotation;* *Pelvic tilting;* *Single knee lifts.*	Warm-ups are performed within a range of motion to promote a gentle stretch. Default: 10× each.	No progressions.	Firm chair. No weights used for warm-ups.	Begin each home exercise session with 10× each warm-up
Strength exercises				
Sit-to-stand. Begin seated. Lean forward and push up to a standing position, using hands if necessary. Slowly lower back down to chair.	Participant performs three repetitions (reps) and rates their perceived exertion (RPE). Repeat process until five to six RPE (moderate exertion) is achieved, using weights if necessary. *Recommended baseline setting*: 1 × 10 reps.	Maintain five to six RPE by increasing weights, increasing repetitions, increasing sets, and/or adding speed on the concentric phase of the exercise to introduce the element of muscle power. *Recommended maximum target*: 3 × 10 reps at speed.	Dumbbells (1 to 5 kg) or weight belt (1 to 12 kg) or weight vest (1 to 18 kg); firm chair with arms; cushion to raise seat height.	Weights: milk bottles, bags of rice, tinned food. Perform in morning or evening sitting on edge of bed; at table when sitting down for meals, in ad breaks when watching TV.
Knee extension. Begin seated. Straighten one leg, then lower it. Repeat with other leg.	Same process as above. *Recommended baseline setting*: 1 × 10 reps.	Maintain five to six RPE using same process as above. *Recommended maximum target*: 3 × 10 reps at speed.	Ankle cuffs (1.5 to 5 kg); firm chair with arms.	Perform in morning or evening sitting on edge of bed; at table when sitting down for meals, in ad breaks when watching TV.
Hip abduction. Stand in front of plinth or table, feet facing forward, body upright. Lift one leg out to side, then slowly lower back to centre. Repeat with other leg.	Same process as above. *Recommended baseline setting*: 1 × 10 reps.	Maintain five to six RPE using same process as above. *Recommended maximum target*: 3 × 10 reps at speed.	Ankle cuffs (1.5 to 5 kg); adjustable plinth or parallel bars station	Perform when standing at the kitchen bench, bathroom sink, or dining table.
Hip extension. Stand in front of plinth or table, feet facing forward, leaning on forearms. Keeping back still, extend one leg straight behind. Slowly lower. Repeat with other leg.	Same process as above. *Recommended baseline setting*: 1 × 10 reps.	Maintain five to six RPE using same process as above. *Recommended maximum target*: 3 × 10 reps at speed.	Ankle cuffs (1.5 to 5 kg); adjustable plinth or parallel bars station.	Perform when standing at the kitchen bench, bathroom sink, or dining table.

Balance exercise				
Static series:  feet together Semi-tandem stance   Full tandem stance ***Active series:*** forward and backward tandem walking.	Perform feet together stance for 10 seconds. If unsteady/reliant on support, this is baseline position. If steady, advance to next foot position and repeat process. *Recommended maximum baseline setting*: static full tandem stance for 3 × 10 second holds.	Maintain a balance challenge by advancing to active series when participant is competent in static series. Begin with forward full tandem walking, 10 steps. When competent, add backward full tandem walking, 10 steps. *Maximum target*: 3 × 10 steps each direction.	Adjustable plinth or parallel bars station	Perform next to a stable surface, such as kitchen bench or wall.
Flexibility exercise				
Static leg stretch (hip flexor and calf muscles). Stand in front of plinth or wall, feet facing forward, hands on surface for balance. Lunge forward onto right leg. Keep left leg straight, push left heel to floor until a stretch is felt at front of hip and/or calf. Repeat with other leg.	*Default baseline setting:* 3 × 10 second hold each leg.	If stretch sensation diminishes, move deeper into the lunge position until the stretch is felt again. *Maximum target*: 3 × 30 second holds each leg.	Adjustable plinth, parallel bars, or wall.	Perform at any stable surface or wall, such as kitchen bench, bathroom sink, or dining table.
Walking				
Walking circuit, laid out on a flat surface to allow use of walking aids, with integrated obstacles to progressively challenge mobility.	Determined by observation of participant mobility and 'soft' signs of exertion. Modifiable parameters include duration of walking, duration of rest, walking speed, and negotiation of obstacles. Walking aids may be prescribed. *Recommended baseline setting:* 10 minutes walking, inclusive of rest periods.	Progression determined by observation of mobility and exertion. *Progress endurance:* walking duration, distance, or speed; *Progress balance:* negotiation of obstacles or uneven surfaces; *Progress strength:* use of hand weights, stairs, inclines. *Maximum target*: 20 minutes non-stop walking with a speed element.	Dumbbells, traffic cones, hoops, steps, rope ladders, lap counters, stop watches.	Walk an extra bus stop; Park in far corner of car parks; Take the dog for a walk; Take stairs instead of lift or escalator; Plan a walking route with places to rest, such as a park bench.

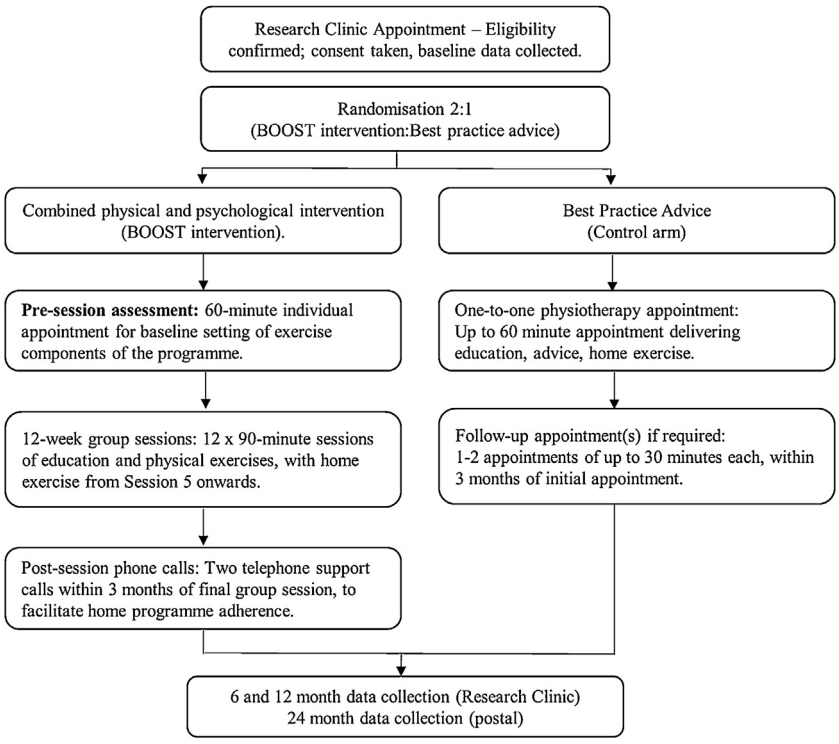

Fig. 1. Overview of the BOOST trial.

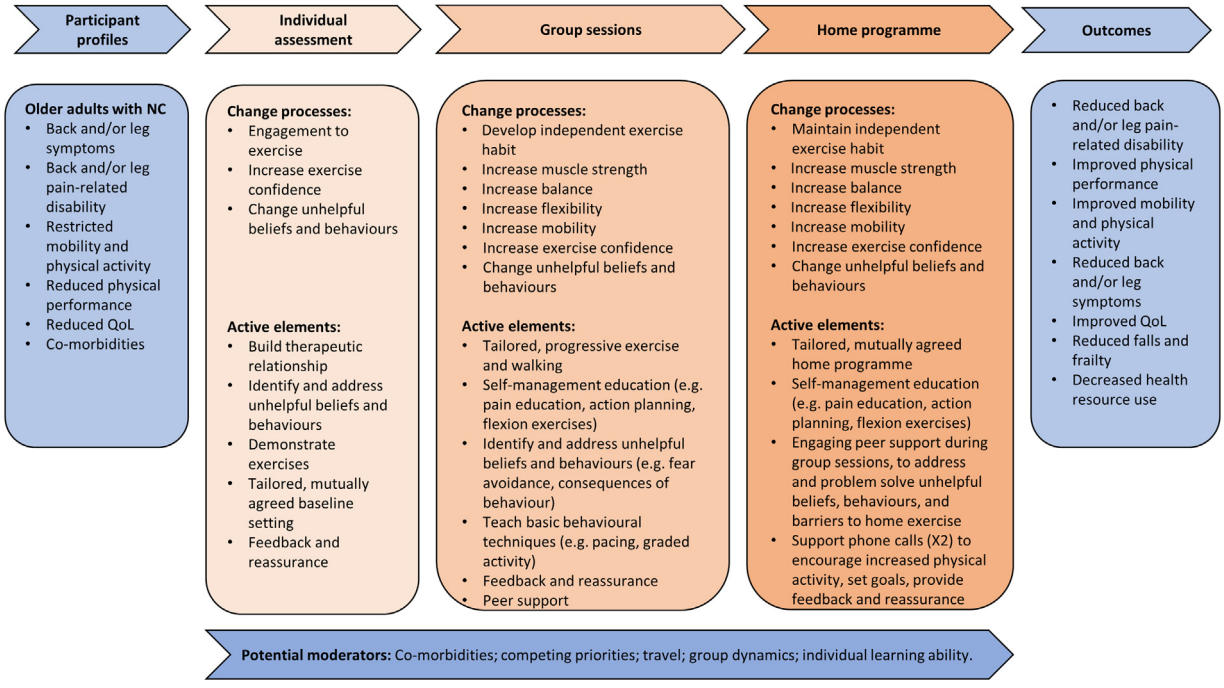

Fig. 2. Conceptual model of BOOST intervention.
Legend: a conceptual model of the change processes and associated active intervention elements supporting participants' transition from supervised group to independent home exercise. The home programme, introduced from Session 5 onwards, uses peer support and physiotherapist instruction to facilitate home adherence. Targeted outcomes are represented on the right, with potential moderators represented at the bottom of the model.

tion and peer support to counter negative beliefs about pain or aging that may impede exercise engagement and adherence, underpinned with behaviour change techniques and pain management principles [15,22]. These two approaches were discussed and refined at an intervention development day attended by research staff, clinicians, physiotherapists,

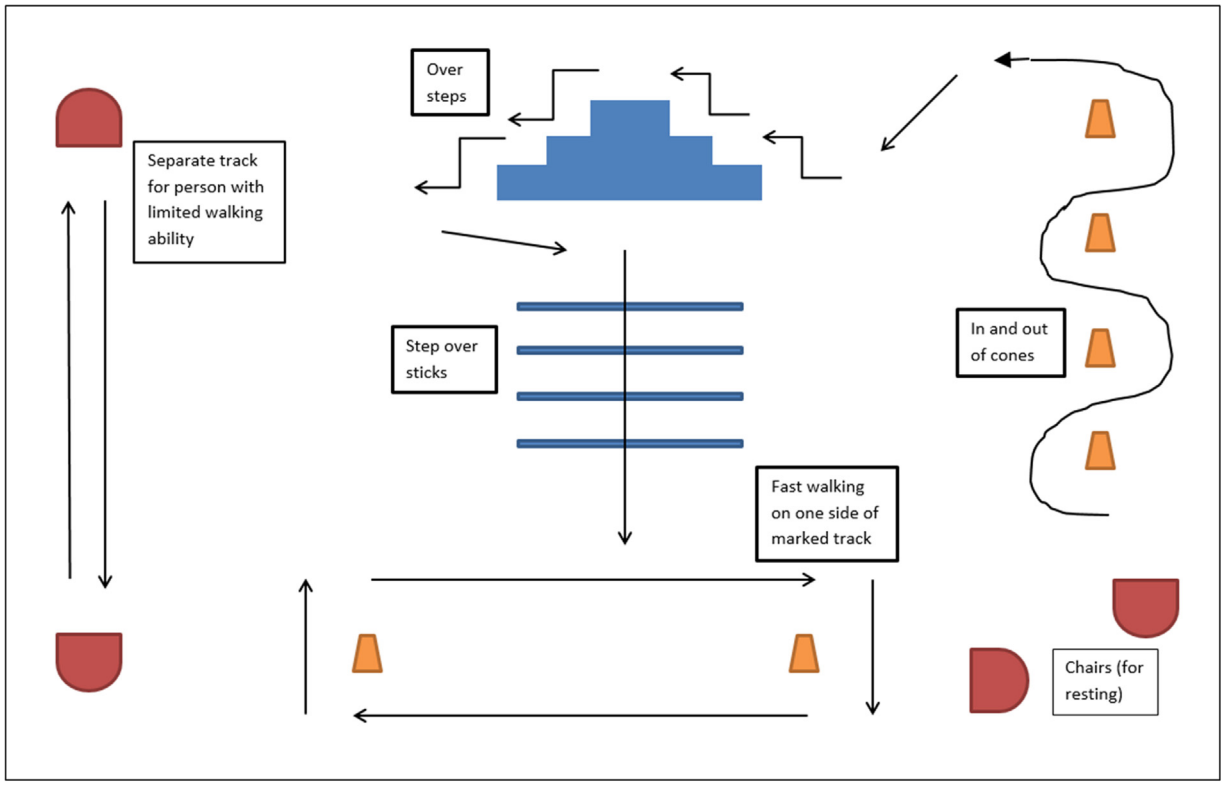

Fig. 3. Walking circuit exemplar.
Legend: the use of mobility challenges and chairs creates a walking circuit suitable for a range of mobility levels. Suggested challenges include hand weights, steps or inclines, cones, hoops, and/or rope ladders. Lap counters and stop watches may be used to self-monitor activity levels and progress.

and Patient and Public Involvement (PPI) representatives, and a draft intervention proposed. This was further refined by study co-applicants, then pilot tested in a clinical NHS setting.

PPI input was integral to the BOOST intervention. Two PPI representatives with spinal stenosis contributed to the programme development day. Four PPI representatives with back pain and/or spinal stenosis contributed to the development of age- and condition-appropriate intervention materials, including modelling for exercise photos.

Rationale underlying the physical content of the BOOST intervention

Active independence is a key concern for older adults, who identify mobility as critical to maintaining their independence and engagement with meaningful activities [20,23]. Accordingly, the BOOST intervention focusses on treatment targets to improve mobility and physical activity levels, through targeting muscle strength, flexibility, balance, and endurance [17,24]. Specific exercises were chosen for their ability to be individually tailored, and performed safely and correctly in both a supervised and unsupervised environment [17].

Strength exercises

Reduced muscle mass and strength, commonly seen in older adults, is often attributed to age-related changes [21]. However, inactivity, rather than ageing, may be a predominant cause [25,26]. Inactivity is exacerbated by pain, leading to a spiral of decline in function and mobility.

Progressive resistance training, using weights or body weight to improve muscle strength, may effectively reverse functional decline and improve functional outcomes in older adults [21,24,26]. As muscles strengthen, exercises are progressed by manipulating intensity, frequency, and volume (sets and reps) [26]. Exercises targeting muscle power, such as introducing speed to the concentric phase of movement, may further improve functional outcomes in older adults [26,27].

Exercise guidelines recommend older adults perform 8–10 major muscle group exercises, 8–12 repetitions each, at moderate to vigorous intensity, at least twice weekly [17,24,26]. However, strength training incorporating power training once or twice per week, with only one or two exercises, may achieve equivalent or better functional gains, and promote adherence, in a frail, deconditioned population [27].

Based on these considerations, the BOOST intervention contains four lower limb strength exercises (Table 2). Participants work to a moderate target intensity (‘feels hard’), operationalised as a 5–6 Rating of Perceived Exertion (RPE) on a modified Borg scale, a valid and reliable measure for RPE in both resistance exercise and older adult populations [26,28].

Balance exercises

Reduced balance is linked to poor mobility in patients with NC [4], and associated with an increased falls risk in older adults [29]. As improving balance can reduce falls and enhance mobility in older adults [30], the authors have included a series of static and active balance exercises [24,31] (Table 2).

Flexibility exercise

Hip and lumbar range of movement (ROM) are identified treatment targets for NC [6]. Shortening and weakening of muscles around the hip may increase anterior pelvic tilt and lumbar extension during walking, reducing the cross-sectional area of vertebral canals and placing pressure on the nerves and vessels within [2]. Restoring hip extension may reduce the amount of lumbar extension needed to maintain an upright position, thereby reducing canal compromise and neural compression [6]. The authors target hip extension through a combined hip flexor and calf stretch (Table 2).

Conversely, lumbar flexion typically improves NC, by increasing the foraminal area and improving haemodynamics [6]. Hence lumbar flexion exercises are commonly prescribed for NC [32]; and the authors have included a simple seated and lying flexion exercise for symptom relief.

Walking

Impaired walking is an identified treatment target for older adults with NC [2,20]. Walking potentially reduces NC by improving blood supply to the spinal vessels impacted by LSS [6]. Walking may also mitigate age-related loss of hip ROM [33], thus complementing the flexibility exercise in the BOOST programme.

Our intervention includes a 20-minute walking circuit (Table 2). The suggested layout is a flat indoor surface, with rest stations, mobility challenges, and room to manoeuvre walking aids (Fig. 3). Participants may walk outside if adequate supervision can be provided.

Rationale underlying the psychological content of the BOOST intervention

The BOOST programme actively targets the development of habitual physical activity, delivering education and evidence-based behaviour change strategies through physiotherapist-facilitated group discussion [18,24]. Group discussions specifically address modifiable psychological, social, and behavioural factors common in people with NC [20,34].

Content is purposely ordered to support the progression from supervised to self-managed exercise (Table 1). Initial sessions introduce behaviour change strategies for pain management and independent exercise; while latter sessions use peer support to maximise long-term behaviour change [15,24].

Rationale underlying delivery of the BOOST programme

Delivery format

Key to the BOOST intervention was delivering a potentially physiologically effective dose of individually tailored exercise, while maximising NHS staff resources. Based on our pre-trial qualitative work [20], a combined individual and group-based format was used (Fig. 1). The initial one-to-one clinical and functional assessment enables individualised exercise tailoring; while the 12 group sessions provide a pragmatic and cost-effective way for concurrently delivering tailored treatment to multiple participants.

The group environment also promotes known enablers of exercise adherence and behaviour change in older adults, including peer support, social interaction, and shared experience [18,24,35,36]. Embedding the home exercise programme in the 12-week intervention, and identifying local community activities, utilises these enablers to develop a habit of independent exercise [36].

Clinical input from the intervention development day considered six to eight participants as a feasible group size for this clinical population. A ratio of one physiotherapist to six participants was recommended; however higher staffing ratios may be required dependant on participants' functional ability.

Duration

Short duration programmes (6 weeks or less) appear ineffective at improving function or mobility in an older adult LSS population [37]. The BOOST 12-week intervention is consistent with the minimum duration required to show substantial improvement in muscle strength through progressive resistance training in older adults [21].

Internal pilot study

An internal pilot with two participants was conducted to test the pragmatics and acceptability of delivering the 12-week intervention within an NHS physiotherapy department. Physiotherapists and participants provided verbal feedback regarding content, equipment use, class duration, and attendance. Feedback indicated satisfaction with the programme content, duration, and delivery. Minor modifications were made to the home exercise planners for participant clarity, prior to full trial delivery.

Delivery of the BOOST intervention

Intervention setting and providers

The BOOST intervention was delivered at community and secondary care physiotherapy outpatient departments across 15 NHS Trusts in England. Intervention providers are qualified physiotherapists registered with the Health and Care Professionals Council, UK.

Provider training

The authors developed a two-phase training programme to ensure standardised intervention delivery across Trusts. Physiotherapists completed a 3-hour on-line training course, covering key behavioural and pain management concepts and strategies including fear-avoidance, pacing, and graded activity. They then attended an intensive one-day course delivered by health professionals qualified in physiotherapy and cognitive behavioural therapy, covering intervention delivery, safety reporting, and trial-specific paperwork. Practical sessions included baseline setting, progression, and circuit layouts for the exercise programme, and delivery of the group discussions. Physiotherapists received a comprehensive training manual, and retained access to the online training resource for the study duration.

Quality assurance procedures

To ensure standardised delivery within and between sites, all physiotherapists are observed delivering at least one individual baseline assessment or group session. Any procedural deviations are discussed with the physiotherapist, and additional visits or training provided as necessary.

A formal fidelity assessment of group delivery is conducted at a second site visit. This structured assessment covers trial administration (e.g. accurate, completed paperwork), education content (e.g. delivery of core session concepts), and exercise and walking circuit content and delivery (e.g. appropriate exercise progression).

Site materials

To optimise standardised intervention delivery, sites are provided with 12 laminated crib sheets outlining the core concepts of each session, a whiteboard, and markers. The circuit exercises use a range of weights commonly available in NHS physiotherapy departments (Table 2). A set of ankle cuffs is provided to participants for home programme use, at the physiotherapist's discretion.

The layout and content of the walking circuit is site-dependent, as per available space and equipment. The authors provided laminated examples of course layouts (e.g. Fig. 3), traffic cones, lap counters, and stop watches. Suggested additions include hoops, rope ladders, and steps (Table 2).

Participant materials

The authors developed two participant resources, in consultation with PPI representatives. At the one-to-one assessment, participants receive an A5 physiotherapy information leaflet, providing general information on LSS and NC, and self-management strategies of activity, flexion exercises, and pain medication. At the first group session, participants receive an A5 information folder, designed to facilitate home exercise adherence. Content includes exercise photos and instructions, key education messages, and home exercise planners.

Intervention tailoring

Intervention tailoring begins at the one-to-one assessment, with individual baseline setting of the exercise and walking contents (Fig. 1). Tailoring continues across the 12 group sessions, through individual progression of exercise sets, repetitions, and loading. The home exercise programme, introduced at Session 5, is likewise progressed, and reviewed during the follow-up phone calls.

Baseline setting

At the one-to-one assessment, the physiotherapist starts to develop a therapeutic relationship with the participant, assessing participant safety and potential barriers to programme engagement. Firstly, a standard clinical assessment is conducted, gathering information on NC presentation, red flag screening, co-morbidities, and current physical activity levels. If indicated, neurological, muscle strength, and ROM examinations are conducted. Next, individual baseline levels for the exercise and walking components are set through a standardised process (described in Table 2). Proper form is emphasised through postural alignment, controlled contraction, and range of motion.

Baseline setting for the four strength exercises is determined using a modified Borg scale, using weights to adjust intensity if needed (Fig. 4). Baseline setting of the balance exercises is determined by physiotherapist observation of the static heel-toe series; and the flexibility exercise (hip flexor stretch) has a recommended default baseline setting of 3×10 second holds per leg.

Baseline walking levels are based on participant-rated ability and confidence, and the physiotherapist's observations (Table 2). Tailoring may include walking duration (including rest stops), walking speed, and use of obstacles; and walking aids may be prescribed or trialled.

Progression

Exercise content is individually progressed to maintain an adequate exercise dose as a participant's ability improves. As per baseline settings, progression is a manualised, standardised process based on physiotherapist observation and participant feedback and RPE ratings. Exercises may also be regressed; for example, during flare-up of symptoms or co-morbidities.

Progression guidelines and targets are detailed in Table 2. Strength exercises are progressed as necessary to maintain the target of five to six RPE (moderate intensity), through increasing weights, repetitions, sets, and/or speed [24]. Balance is progressively challenged through decreasing the base of support and introducing dynamic movement to the bal-

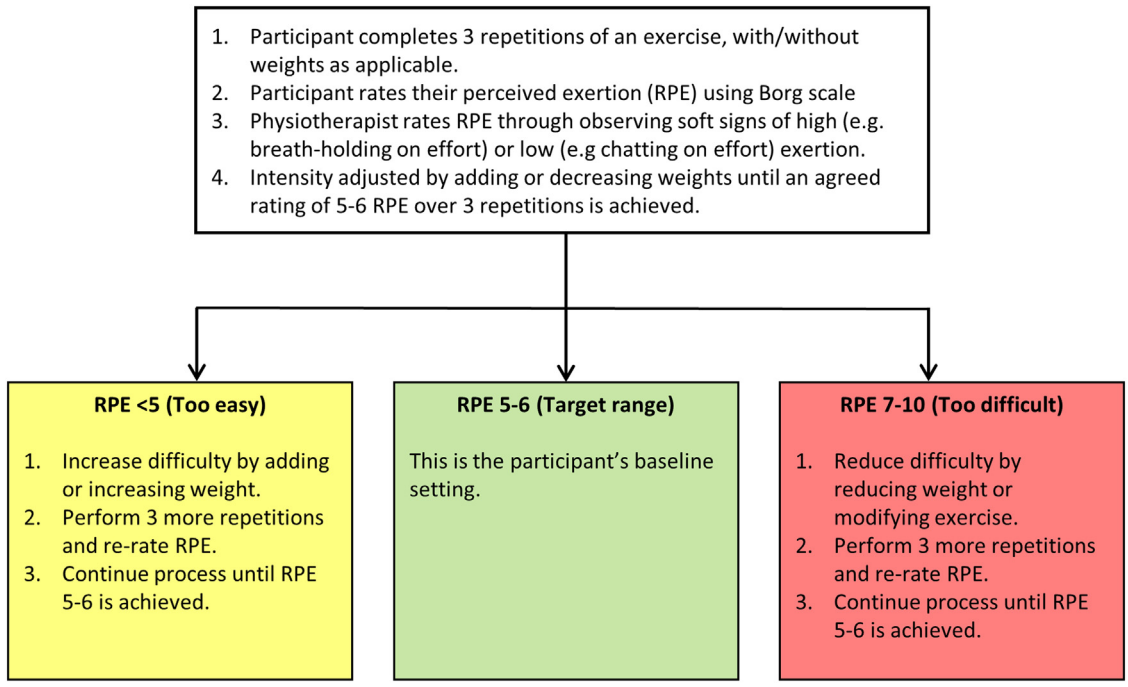

Fig. 4. Baseline setting procedure for the four strength exercises.

ance exercise series. The hip flexor stretch is progressed by increasing the time held in the stretch position.

Participants' walking is progressively challenged through manipulating elements of endurance, leg strength, and balance (Table 2). Examples include introducing stairs into a circuit, or increasing the number of circuit laps walked without resting.

Session structure

Each session begins with participants seated as a group for an interactive 30-minute discussion, supplemented with handouts and whiteboard presentations. Participants remain as a group for the 5-minute warm-ups. They then proceed to the circuits, individually completing their tailored exercise and walking programme in no set order.

At Session 1 the exercise and walking circuits are performed as per baseline levels. They are progressed over subsequent sessions to ensure an adequate stimuli is provided to achieve strength, mobility, and fitness gains. If symptoms are triggered during the circuit programme, participants are advised to perform seated flexion exercises, and recommence the circuits once their symptoms subside.

Home exercise programme

Maintaining habitual physical activity is supported through an individually tailored home activity programme, introduced in three phases across Sessions 5–8 (Table 1). Content is based on the group exercise and walking circuits, as mutually agreed between the participant and the physiotherapist. Participants are encouraged to do their home programme at least twice weekly, at a level the physiotherapist considers safe to be completed unsupervised [24]. Weekly exercise planners are included in the participant information folder.

Home exercise adherence is facilitated using both peer and physiotherapist support. From Session 6 onwards, group discussions focus on building exercise confidence and maintaining physical activity. Discussion topics include feedback on progress, exercise barriers, and goal setting, with signposting to local activity groups and amenities [15,24,35,36] (Table 1). Each participant further receives two telephone calls from the physiotherapist within three months of programme completion, providing support and encouragement for continued adherence to their home programme (Fig. 1). The calls, structured according to a *pro-forma* checklist, address adherence issues, and provide programme tailoring as necessary.

Conclusion

This paper describes the development of a physiotherapist-delivered physical and psychological intervention for older adults with NC. The clinical and cost-effectiveness of the BOOST programme will be evaluated in this largest randomised controlled trial to date of conservative interventions

for NC. Findings will be reported separately following trial completion.

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